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Development of the Umbellifer Fruit.[1]

JOHN M. COULTER AND J. N. ROSE.

(WITH PLATE XIV.)

In no family of plants does the fruit furnish more certain diagnostic characters than in the Umbelliferæ. So definite are they that the fruit alone can be made to determine the genus, and in most cases the species, while in every case it is an essential part of the description. This indicates at once an unusual amount of differentiation in the fruit structures, and a great diversity in its display. During the past year we have been making a critical examination of all our Umbelliferæ east of the 100th meridian, and this has directed our special attention to the minute structure of the fruit of all our species. This study has shown that while the grouping of these structures is very diverse, and hence available for diagnostic purposes, the structures themselves are simple and few in number.

It was a matter of interest to study the development of these peculiar structures, and for this purpose the common Chærophyllum procumbens was selected as a type, as its fruit contains all the structures found in the family. Beginning with ovary wall composed of undifferentiated parenchyma, supported by simple fibro-vascular elements, the changes wrought in the maturing ovary and then in the ripening fruit were traced.

A description of the structure of the mature fruit of Umbellifers in general will make plainer the questions to be answered by a study of its development. The two carpels face each other, and are in contact at first by their commissural or ventral faces, but eventually separate. The fruit is compressed laterally (at right angles to the plane of the commissural faces) or dorsally (parallel with the commissural plane), or not at all. As the two carpels are but repetitions of each other, a description of structure may be confined to a single one. The surface of the carpel is usually marked by five ribs or wings longitudinally placed. The two nearest the commissure are the laterals; a single dorsal one occurs on

[1]Read at the meeting of the A. A. A. S., New York, August, 1887.

the back of the carpel, while the pair between the dorsal and the laterals are the intermediates. In addition to these five primary ribs or wings secondary ones may appear (as in Hydrocotyle Asiatica), and even become more prominent than the primary ones (as in Daucus and Trepocarpus); or occasionally even all external indications of ribs may be lacking (as in Sanicula). The presence of these ribs or wings, their varying size and structure, furnish good diagnostic characters. At the summit of each carpel a stylopodium may be developed, of various appearance, from prominently thick conical to a flat or depressed cushion.

The general structure of the pericarp wall well represents the typical leaf structure, with under and upper (that is, outer and inner) epidermal layers bounding a more or less developed mesophyll (figs. 6, 7). It is in the mesophyll region that the characteristic fruit structures are developed. The constant occurrence in the outer epidermal region of the two distinct layers of epidermal cells suggests that the outer layer represents the connate calyx, while the inner is the true epidermis of the pericarp. The mesophyll region of the pericarp is naturally separated into three structures: (1) oil-ducts, (2) strengthening cells, and (3) undifferentiated parenchyma.

I. Oil-ducts.—These occur in varying number, size and position in the different genera, and are of such constancy as to furnish most valuable characters. By far the most common position for oil-ducts is in the intervals between the ribs, where they occur singly or in groups. In this position they may occur close against the inner epidermal layer, or centrally in the pericarp section, while in Cryptotænia and Erigenia they seem to be developed in the inner epidermal layer itself. In Æthusa, Cœlopleurum and Cryptotænia oil-ducts occur both in the intervals and beneath the ribs. In some cases, as in Polytænia, there are two sets of oil-ducts, one forming almost a continuous layer about the seed-cavity, the other composed of smaller ducts, and scattered through the very thick pericarp. In Zizia there are also smaller accessory ducts in the ribs. In Conium there is no development of oil-ducts, but the whole inner epidermal layer of the pericarp becomes a secreting layer. In Hydrocotyle, on the other hand, in the absence of oil-ducts groups of secreting cells occur just beneath the outer epidermis of the pericarp, and in some species eventually break through it, forming superficial oil vesicles. Anthriscus and some Bupleurums

have neither oil-ducts nor secreting cells. In Osmorhiza the mature fruit usually gives no trace of oil-ducts, while the immature fruit may show groups of four to six oil-ducts in the intervals and one to three in the ribs themselves. The obliteration of oil-ducts on approach to maturity would seem to make them represent aborted organs in this case, and may account for the discrepancy of opinion concerning the oil-ducts of certain genera. It is an interesting fact that this suppression of oil-ducts seems to involve the formation of an oily layer. In Osmorhiza the mature fruit has an oily layer about the seed, a region occupied in the immature fruit by a distinct line of oil-ducts. In Hydrocotyle, however, the isolated groups of secreting cells are such as always precede the formation of oil-ducts. In Hydrocotyle, therefore, the oil-ducts could be called rudimentary; in most Umbellifers they are oil-ducts proper; in Conium a secreting layer has been developed; while the development of the Osmorhiza fruit gives us distinctly all three phases. Hence, to summarize: (1) most genera have distinctly developed oil-ducts, variously placed, (2) a few have a layer of secreting cells, (3) some have groups of secreting cells, and (4) others have neither oil-ducts nor secreting cells, in fact, without any representation of this one of the three structures of the mesophyll.

II. Strengthening cells.—Under this name we would define certain groups of cells, which are unlike enough in structure, but seem to serve the common purpose of strengthening the pericarp wall or its ribs. They usually occur beneath each rib, and are normally developed about the simple fibro-vascular elements of the pericarp wall (fig. 6). These fibro-vascular elements may eventually become obliterated. The group of strengthening cells may consist of fibrous tissue, sclerenchyma, sclerenchymatous parenchyma, or small-celled parenchyma. It may be well marked off from the surrounding tissues, as in the distinct thick-walled groups of Osmorhiza, Cryptotænia, Conium and Chærophyllum (figs. 1 and 7); or it may gradually merge into the surrounding tissue, as in Angelica, Thaspium, etc. In Hydrocotyle, Pastinaca and Heracleum the strengthening cells are developed in a broad continuous band about the seed-cavity; while in Sanicula, Conioselinum and Æthusa they seem to be entirely wanting. In the last named genus they may be found in the very tips of the prominent ribs, the position usually held by strengthening cells being occupied by large and

loose parenchyma, the other structures remaining normal. Strengthening cells are thus unlike in elements and position, are in groups of varying size and distinctness, or in bands, or may be wanting entirely. From these facts important characters may be obtained for generic grouping.

III. UNDIFFERENTIATED PARENCHYMA.—This has merely the negative character of not being transformed into either strengthening or secreting cells. Its abundance is dependent upon the development of the strengthening cells. It will be seen, however, that although it furnishes no diagnostic characters, it is probably most concerned in the growth of the pericarp.

Each carpel primarily contains two ovules, one of which soon becomes aborted (fig. 2), although it is developed sufficiently to display its nucellus and integuments, as well as its anatropous character. The other ovule eventually occupies the whole space of the ovarian cavity.

The fibro-vascular connection of the ovules with the plant axis is as follows: A fibro-vascular bundle enters each carpel at its base, thus making it a lateral out-growth from the axis, while the axis itself continues its growth in the carpophore. The carpellary bundle almost at once subdivides into five branches, and these branches ascend the carpellary wall beneath the five primary ribs.

The two lateral bundles (that is, those beneath the lateral ribs) are the largest, as they contain the fibro-vascular elements to be distributed to the ovules. These lateral bundles pass in the carpellary wall to the very summit of the carpel, and then send a branch inwards and downwards into the funiculus of the anatropous ovule (fig. 2). The remaining elements of the fibro-vascular bundle pass on to the floral organs and stylopodium. It will be seen that in this case, as in Compositæ, the ovules are lateral outgrowths. A point or two in the development of the ovule may be mentioned in this connection. At first both ovules lie at the summit of the ovarian cavity, but soon, by the development of the funiculus, one is thrust toward the bottom, with the micropyle near the center of the cavity (fig. 2). It is in this position that the pollen tubes are seen to enter the micropyle, and subsequently the ovule develops so as to fill the ovarian cavity. The aborted ovule is retained at the summit of the cavity, its funiculus never developing, and its micropyle out of reach of the pollen-tubes, even if its nucellar structures were developed to receive them.

To recur now to the mature seed, it will be found to consist mainly of a much developed embryo-sac, filled with endosperm and a small embryo. The embryo-sac never entirely replaces the nucellus, more or less of the nucellar tissues being found on the commissural side, either pressed against the flat or concave face of the embryo-sac or embraced in its infolding (figs. 12, 13, 14). Important characters have been obtained from the commissural face of the seed, based upon the fact that it may be convex, plane, concave, or more or less involute. Great care should be exercised, however, to obtain seed of perfect maturity, or a comparison on this basis will amount to nothing. All seeds at first have a convex or plane face, and the amount of concavity or infolding will depend upon the development of the embryo-sac. In some cases the embryo-sac, instead of developing uniformly, develops strongly towards the commissure on the two sides, resulting in a concave or involute seed-face. This variation may occur in the mature fruits of a single species (as in Eulophus), so that there may be found plane or concave seed-faces in one and the same plant.

Having described the structures to be found in the mature fruit in general, it remains to describe the method of their development in Chærophyllum procumbens.

1. Development of oil-ducts.—In very young buds groups of 3 or 4 parenchyma cells of the pericarp, next the inner epidermis, begin to be set apart for the formation of oil-ducts (fig. 3). The first indication of this is in the fact that they become secreting cells, and are discolored by the characteristic oily contents, and also become larger than the surrounding parenchyma cells. The 3 or 4 secreting cells then begin to divide radially, so that, at about the time of anthesis, the resulting intercellular space becomes an oil-duct of small caliber, with 6 to 8 secreting cells (fig. 4).

This radial division continues as the fruit matures, thus gradually enlarging the caliber of the duct, until it reaches its full size, with a dozen or so secreting cells (fig. 5). The ducts are thus enlarged intercellular spaces, developed by the radial division of the surrounding secreting cells, and simply act as reservoirs.

In Hydrocotyle (in which there are only groups of secreting cells and no ducts developed) the absence of ducts seems to be explained by the lack of power of radial division in the secreting cells. In Osmorhiza this power is also poorly developed, so that while the ducts are at first outlined, they

are presently encroached upon and obliterated by the development of contiguous cells, thus forming a continuous oily layer composed of obliterated ducts and intervening secreting cells. In Conium no ducts are developed, because groups of cells are not set apart as secreting cells, but only a single layer of cells, and there can thus be no development of intercellular spaces, although the power of radial division is retained. Hence Hydrocotyle has no oil-ducts because its secreting cells lack the power of radial division; Conium has none because its secreting cells are in a plane instead of in groups; while most Umbellifers have oil-ducts because their secreting cells are in groups, and also have the power of radial division. The only other phase is the entire absence of secreting cells, as in Anthriscus and certain Bupleurums.

II. DEVELOPMENT OF STRENGTHENING CELLS.—In young buds there is no setting apart of this region from the ordinary parenchyma of the pericarp wall (fig. 8). Upon approaching anthesis, however, the parenchyma cells surrounding each fibro-vascular bundle sub-divide (fig. 9), and at anthesis quite a distinct group of small parenchyma cells is discovered beneath each rib (fig. 10). This comparatively small size is due not only to cell division and moderate growth but also to the strong growth of the surrounding undifferentiated parenchyma. While the region is indicated before anthesis it does not become really a region of strengthening cells until the development of the fruit. It is then that the walls begin to thicken, until at maturity a group of strengthening cells is composed of firm, heavy-walled tissue (fig. 7). The contained fibro-vascular elements are encroached upon, and for the most part obliterated, as they are really functionless after anthesis. This differentiation proceeds centrifugally from the fibro-vascular elements as a center, at first a comparatively small area being included. The surrounding parenchyma is gradually invaded, until in some cases the whole thickness of the pericarp wall is concerned (figs. 1 and 11). The amount of primary parenchyma transformed into strengthening cells varies widely. In Chærophyllum this structure reaches probably its maximum development, occupying the whole thickness of the pericarp wall, separating the undifferentiated parenchyma into isolated patches, and also being very thick-walled. In certain genera the strengthening-cell groups of the mature fruit are in the same condition as those of Chærophyllum at anthesis, viz.: differing from the surrounding parenchyma only in smaller size, and

never becoming thick-walled, as in Angelica. Continuous bands of strengthening cells, as in Hydrocotyle, are always developed next to the seed cavity, in the same position as the continuous secreting layers. Hence we find strengthening-cell structures developing in bands or groups, and when in groups they may become thick-walled or not. In certain genera this kind of differentiation is entirely lacking, while in Æthusa we find the anomalous feature of the strengthening-cell regions developing a large-celled and loose parenchyma.

III. Development of undifferentiated parenchyma.—This region, lying between the strengthening-cell groups, is chiefly concerned in the development of the pericarp wall in size. After anthesis there seems to be but little increase in the thickness of the pericarp wall, the growth being chiefly extension. This extension is effected by the radial division of the undifferentiated parenchyma cells, the amount of tangential cell division being comparatively small. The exception to this is found in ribs and wings, which represent regions of strong tangential cell division in the undifferentiated parenchyma.

In this way the three structures of the pericarp wall are built up, and in their endless, but simple and constant variations, we find a clew to the classification of a group of plants otherwise hopelessly confused.

Explanation of Plate XIV.—All the figures are from Chærophyllum procumbens Fig. 1, Cross section of mature carpel, showing large strengthening cell areas; small solitary oil-ducts in the intervals, two on the commissural side; and a deeply sulcate seed-face. Fig. 2, Longitudinal section of carpel at anthesis, showing abortive ovule; developing ovule thrust down into ovary cavity ready to receive pollen-tubes seen at summit of stylopodium, and which should have been represented as passing through the ovary cavity and entering the micropyle; and fibro-vascular connections of ovule. Figs. 3, 4 and 5, Development of the oil-duct. Fig. 6, Section of ovary wall at anthesis, showing beginning of a strengthening cell group about the simple fibro-vascular elements; a developing oil-duct; and inner and outer epidermal layers, the latter of two layers, probably indicating a connate calyx. Fig. 7, Mature strengthening cells, sharply marked off from surrounding parenchyma. Figs. 8, 9, 10 and 11, Development of strengthening cell area, fig. 10 being taken at anthesis. Figs. 12, 13 and 14, Cross sections of developing seed.

Insect relations of certain Asclepiads. II.

CHARLES ROBERTSON.

On the ground of usefulness to Asclepias, butterflies may be thrown into three divisions. The Papilios are the most useful, and pollinia were found on all of our species except Ajax. They suck with their wings in motion. Using their legs to offset the motion of the wings, they rapidly repeat those movements which are necessary to draw the pollinia from the anther cells and insert them into the stigmatic chambers. Other large butterflies, like Danais, hold their wings still in sucking, spending more time on an umbel, but generally carrying pollinia. Small butterflies are worse than useless. They remain long on the umbels, sucking, but resting their feet superficially on the flowers, and seldom effecting pollination. Of twenty-three species bearing pollinia, only three are smaller than Chrysophanus Hypophleas; while of twelve species on which no pollinia were found, with the exception of Eudamus Tityrus, which was not caught, the Chrysophanus is the largest. As stated before, butterflies have corpuscula on their claws less frequently than Hymenoptera.

Since several moths were found entrapped on the flowers, pollination must often be brought about by night-flying Lepidoptera.

As a rule, Diptera either do not transfer pollinia at all, or become hopelessly entangled when they do. I have specimens of Eristalis, Trichopoda and Sarcophaga with several pollinia. In contrast with Bembex, mentioned above, certain flies, which resemble wasps in form and colors, also imitate them in their movements on the flowers and extract pollinia more readily than other flies. These are Physocephala, Conops and Midas. The legs of Midas clavatus sometimes bristle with pollinia of A. verticillata and incarnata. Corpuscula were found on the pulvilli, hairs and tongues of flies, never on their claws.

Beetles which visit the flowers to gnaw, as Tetraopes, are injurious, while those visiting them for nectar, Trichius, Euphoria and Chauliognathus, are quite as useful as any flies.

Among Hemiptera, Podisus, which frequents the flowers

to prey upon insects, and Lygaeus, which sucks the hoods regularly, both transfer pollinia.

It is evident that the flowers of Asclepias are adapted to fasten corpuscula upon the legs of insects, and that they catch the tongues only accidentally. However, I have found corpuscula on the tongues of one species of butterfly, two species of beetles, five flies, and twenty Hymenoptera.[10] Bees and wasps move about with their tongues partly extended, and it is natural, especially on the smaller flowers, that some of the appendages which they bear should be caught by the wings. Moreover, combinations of corpuscula are found on the tongues showing that pollination has been effected repeatedly in this way. I have a specimen of Bombus vagans with five corpuscula on tongue, one of B. Virginicus, with a combination of four corpuscula and one single corpusculum, and a Sphex with a combination of five corpuscula. In general, however, extraction of pollinia by the tongue appears to be of little or no use.

ACERATES LONGIFOLIA.—If we compare a flower of this plant with one of Asclepias, it will be apparent that the flowers are not particularly adapted to fasten their corpuscula on the legs of insects (fig. 3).[11] The hoods have no horn, and their tips are pressed against the gynostegium so as to close them. The angles of the wings, instead of being set between the bases of the hoods, are above them. The hoods, therefore, have the sole function of nectaries, and do not serve, as in Asclepias, to guide the legs over the slits.

The anther wings, from the corpusculum to the angle, measure hardly one millimetre, and are adapted to catch fine hairs, not the coarser processes.

Bumble-bees insert their tongues into the closed nectaries with great facility. They are the most common visitors, and the flowers seem to be especially adapted to them. A bumble-bee clasps several flowers between its legs, and, as it moves over the umbel, the abundant hairs on the under side of the thorax, abdomen and basal joints of the legs enter the slits and draw out the pollinia; so that the ventral surface of the bee fairly bristles with them. Fig. 4 is a sketch of Bombus scutellaris, showing the positions of attachment of the corpuscula. The specimen from which it was drawn has more than one hundred pollinia, with many corpuscula which have lost their pollinia, and is not an uncommon case. Hive-bees sometimes visit the flowers. On one I found thirty-three pol-

[10] Hildebrand found pollinia of A. Cornuti on tongues of bees. Bot. Zeit., 1866, No. 48.

[11] The figure references are to plate xii, issued with the September number.

linia, on another fifty-four. I have also found a pair of pollinia on a hair of the abdominal brush of Megachile. Next in abundance to bumble-bees, is Bembex nubillipennis, which rests so lightly on the flowers and has such short hairs that I have failed to find pollinia upon it, except in one case, mentioned below. One beetle, Trichius piger, caught on a Pycnanthemum, has eight corpuscula and eight pollinia on ventral surface. Butterflies rarely force their thin tongues into the nectaries, but do not extract the pollinia. Flies were not seen sucking.

In Acerates viridiflora, the tips of the hoods rise to the level of the style-table, while in this species they hardly reach to the angles of the wings, and it is interesting to observe the effect. In sucking, the insect's head is brought down so close to the tips of the hoods that the hairs on its face and tongue are often caught by the wings; indeed, it seems more natural for visitors of this Acerates to have pollinia on their tongues than for those of Asclepias. Pollinia were found on the hairs of the labrum and tongue of Bombus separatus, and on the labrum of Bembex nubillipennis. Fig. 5, a sketch of the face of Cerceris bicornuta, indicates the positions of attachment of three corpuscula with five pollinia. The specimen also has pollinia on the tongue, and five corpuscula with eight pollinia on ventral surface.

I have seen no combinations of pollinia of this plant, and it does not seem to need them, as it can attach an abundance of corpuscula directly to the hairs.

The pollinia turn with their blades parallel in about a minute after extraction. When the bee moves over the flowers a retinaculum with its pollinium is caught as the hair was before. When the pollinium has entered the stigmatic chamber and will go no further, the retinaculum is broken, leaving the pollinium in the cavity, and escapes from the slit without withdrawing the corpusculum at the top. That the corpusculum does not enter the chamber, but that each pollinium is inserted singly, I am satisfied is true in this plant as well as in Asclepias. It is hardly possible to see pollination effected, as in Asclepias Sullivantii, but I have found pollinia under conditions which indicate that they are introduced in the same manner. A pollinium is sometimes found in the stigmatic chamber with pollen tubes emitted, with its retinaculum projecting through the slit, and the corpusculum and the other pollinium hanging outside. Broken hairs in the cleft of the corpusculum show that it has lost its hold on

the insect, instead of the retinaculum breaking and leaving the pollinium behind. Mansel Weale found pollinia of *Xysmalobium linguæforme* Harv., attached to the long hairs of the sternum and coxæ of a Pallasoma, but they gain this position accidentally, the flower being adapted to fasten pollinia to some part of the insect's head.[12]

Insects with short hairs sometimes suck without drawing out the pollinia, which shows the importance of those with long hairs (bumble-bees).

In all fifteen species of the following genera were caught on the flowers, those bearing pollinia having been mentioned:

Hymenoptera: Apis, Bombus (2), Megachile (2), Polistes, Odynerus, Cerceris (2), Bembex, Myzine. *Coleoptera:* Trichius. *Lepidoptera:* Thecla, Chrysophanus, Scepsis.

ACERATES VIRIDIFLORA.—The flowers are much larger than in the preceding. The wings measure about one and three-fifths millimetres from the angle to the top, and are adapted to catch the hairs of the legs of insects, not the claws or ventral hairs.

The hoods extend from the bases of the petals to the tips of the anthers, are pressed close to the gynostegium, and are about five millimetres deep.

The pollinia are two and three-fifths millimetres long, and are narrowed above for about half their length into a slender stock. From above the stock is devoid of pollen grains for about one millimetre. The retinacula are very short, serving mainly to keep the pollinia apart, so that both may not be drawn into the same fissure. The stock of the pollinium serves the place of a retinaculum, and lets the granular part of the mass down below the angle of the wings. When drawn up this slender part is caught by the wings, as the hair bearing the corpusculum was before. The base of the mass is drawn into the chamber, and is wedged fast. Then the retinaculum separates from the pollinium, leaving it behind with the long caudicle projecting beyond the anthers. After insects have visited the flowers the presence of a pollinium in the chamber is indicated by this stalk. Sometimes the corpusculum loses its hold on the insect, when we find the pollinia in the condition shown in fig. 6, one with its base emitting tubes, and the corpusculum and other pollinium outside. While the stalk seems to be very useful in effecting pollination, it seems to act injuriously in every case in which a corpus-

[12] "Observations on the mode in which certain species of Asclepiadeæ are fertilized." *Jour. Linn. Soc.*, xiii, 52.

culum is present at the top of the slit, for it enters the cleft and carries the corpusculum up out of its proper position, as shown in fig. 7 (plate xii). Such cases may be found on flowers which insects have visited. Combinations of pollinia can hardly be formed.

Compared with other Asclepiads we have studied, this shows a few peculiarities which we may sum up: (1) The upper part of the pollinium serves the purpose of a retinaculum and is without pollen grains. (2) The pollinium does not fit the stigmatic chamber, but, when in a position to emit tubes has its upper end projecting above the style-table. (3) The retention of the pollinium is effected by its own thickness, and not by a rigid part of the retinaculum which remains attached to it.

I have five specimens of Bombus separatus and three of B. scutellaris, all with pollinia on hairs of legs.

While the hoods of the species of Acerates do not enable them to catch the hairs and pollinia with the same precision as in Asclepias, they compensate for this by restricting the visitors to the most diligent bees, which are provided with an abundance of long hairs.

There are some peculiarities in the adaptations of Asclepiads, which may be brought out by comparing them with ordinary flowers, or with the orchids. If an insect inserts its tongue into the nectary of a Habenaria, it is fairly certain that it will draw out one or both pollinia, and, when sucking another flower, will bring the pollen in contact with the stigma. In the case of Asclepias the most efficient visitor may suck the hoods without drawing out a pollinium, and, then, the chances of a particular pollinium being inserted are not many. Pollination is only fairly certain when the leg is provided with many pollinia. The accidental nature of pollination is to a certain extent conducive to cross fertilization. If we suppose that an insect visits a number of plants, a given pollinium will be more likely to be carried to a distinct plant.

One act of pollination supplies enough pollen to produce good fruit. Mr. Corry has observed that one pollinium is sufficient to fertilize a flower of Asclepias Cornuti.[13]

There are two ways bees have of treating loose pollen, to which the pollinia of Asclepiads are not liable: (1) It is

[13] Trans. Linn. Soc., Lond., Bot 2d. Ser., II, 196. This bears directly on what I have insisted upon, that the pollinia are inserted singly by the knees, and not in pairs by their corpuscula.

well known that they wipe loose pollen from the hairy surface of their bodies to apply it to their pollen collecting apparatus. (2) I have seen Bombus vagans, after visiting several flowers of Triosteum perfoliatum, stop and brush the pollen from her face and tongue without placing it in her corbicula. Bombus Pennsylvanicus was seen to insert her tongue between the introrse anthers of Dodecatheon Meadia, and then hang with her four posterior feet fixed to the flowers and wipe off the pollen with her front legs simply to get rid of it. In contrast with this I have seen bumble-bees trying in vain to free themselves of the pollinia of Acerates longifolia, by which they were evidently annoyed.

As far as the mere application of pollen to an insect is concerned, a flower with loose pollen has the advantage. But the advantage is on the side of Asclepias after the insect is loaded with it. It is only a general rule that insects keep to flowers of a particular species, on their honey and pollen-gathering expeditions. If a bee dusted with loose pollen visits flowers of another species, it will not long retain pollen in sufficient quantity to effectually fertilize flowers of the original species. On the other hand, if an insect returns at any time during the day, or even after a few days,[14] to the species of Asclepias from which it got a load of pollinia, it may bring with it all or most of the pollinia which it has carried from the first plants. The firmness with which the pollinia keep their hold on the insect is one of the best adaptations for cross-fertilization.

Since different species are in bloom at the same time, it is necessary to be very certain that the pollinia on an insect belong to the plant on which it is found. A Scolia caught on Asclepias verticillata had pollinia of this plant and of A. Cornuti on its tarsal hairs. A Papilio found on A. Cornuti had only pollinia of A. tuberosa. A specimen of Bombus scutellaris shows how insects change flowers and emphasizes the advantage in the structure of the pollen-masses of Asclepiads. Its pollen baskets show the yellow pollen of the Petalostemon on which it was caught, and dark pollen from some other plant; and it has, besides, pollinia of Acerates longifolia on ventral surface and of A. viridiflora on hairs of tibiæ. It is interesting to observe that, while the loose pollen was packed in the corbicula to be carried away and left in the

[14] Pollinia of Asclepias Sullivantii, which were extracted and exposed to the air on June 23, were inserted into the stigmatic chambers on July 7, two weeks after extraction, and emitted pollen tubes.

nest, the pollinia of the two Acerates kept their proper position. Now, when such insects visit flowers of the species to which the pollinia belong, full fertilization may take place—cross-fertilization, too, since they have wandered so far from the original plants.

The modifications of the floral structure of different species enable the plants to avoid competition for the same insects, or for the same parts of the same insects. Thus, bumble-bees have pollinia of Asclepias Sullivantii on their claws, of A. verticillata on their tarsal hairs, and of Acerates longifolia on the hairs of the ventral surface.

As an interesting peculiarity of Asclepiads may be mentioned, the occurrence of pollinia in positions in which the flowers are not specially adapted to place them. It has been observed that Asclepias sometimes fastens pollinia on the tongues of insects. Acerates longifolia accidentally catches the hairs of the face and tongue. In contrast with the Acerates, is Xysmalobium linguæforme, whose pollinia, according to Mansel Weale,[15] are found regularly on the insect's head, but only accidentally on the hairs of the tarsi and ventral surface.

BRIEFER ARTICLES.

"Indicative" Eriogonums.—The mountains of Montana are not very high, but they are numerous, extending over a large portion of the territory. Almost wherever prospected they yield precious metals, in some form or other, to the eager searcher after wealth. Even the plains have been found to hide within their vast expanses valuable iron ores and coal.

In the August GAZETTE certain "indicative plants" were spoken of. Eriogonum ovalifolium was considered indicative of silver ore in the soil. We have at least three species of the genus in northern Montana, and I am prepared to state that none of them are indicative of anything of the kind. In 1885, Dr. Frank Pottle, in company with the writer, found a large vein of magnetic iron ore in the Belt mountains. The ore also contained small per cents. of copper and silver. Thickly covering the surface soil of this "lead" were large beds of Eriogonum umbellatum in an unusual degree of luxuriance. It was towards the end of June, and the many creamy-flowered umbels were at their best. It is highly probable that had some knowing old prospector hunting "signs" as well as gold

[15] Loc. cit., p. 52.

discovered this vein, he would have set Eriogonum umbellatum down as a good sign. But it is no sign at all, for it is profuse almost everywhere in the mountains, where there is quartz or other ore, or where there is none. This species appears to confine itself to the mountains, and is common in the Belts and Birdtails, and the ranges about Helena. E. flavum is also common, and certainly is a pretty plant. We find it mainly on the plains and in the foot-hills. While E. umbellatum seems equally partial to rocky and loamy soil, E. flavum is found in rocky or gravelly ground almost exclusively. Like so many of our western plants it has wonderfully long, tough roots, considering its size, which penetrate the soil to a considerable depth, nothing daunted by the stones or other impediments in their downward course. The roots of this plant are covered by a loose, papery bark, brown or blackish in color, beneath which the surface is reddish. I have found them nearly two feet in length, and about an inch thick just below the crown of dead leaves which characterize this and E. ovalifolium alike. I have never found the latter growing so abundantly in the mountains as E. umbellatum, but it is extremely plentiful on the plains, growing with E. flavum. Generally speaking, it is a smaller plant than the two preceding, although the peduncle often exceeds that of E. flavum. It may be readily distinguished from the latter by its white appearance, smaller and denser umbels, and small roundish leaves. Often it is remarkably cespitose, forming small hillocks through the accumulation of dead leaves and the earthy substances lodging amongst them. It has been said that reliable Montana prospectors regarded this plant as a good indicator of silver in the soil. It may be so regarded by some, although none of that persuasion have crossed my path; but I am convinced that the growth of this plant is no sign. If it were, then all northern Montana would rest upon a bed of silver. In this vicinity carbonate iron stones underlie the surface, and below them are huge deposits of coal. In some places coal veins eighteen feet thick have been disclosed. A professional assayer, who has assayed many samples of these irons, told me, upon special inquiry, that they averaged from 40 to 60 per cent. in iron. In some instances he found small per cents or mere traces of silver, but in the majority of cases he found none.

This portion of Montana has been prospected over for years, plains as well as mountains, and if silver were as plentiful as the abundance of Eriogonum ovalifolium seem to indicate, it would have been brought to light long ago. So far as prospecting is concerned, it is largely a game of chance. It is, in fact, mere gambling. I have heard of cases where professional geologists from Washington have examined a portion of country with a hammer; tapping here, chipping there, and with that and their scientific knowledge of formation combined, have concluded no precious metals were there; while shortly afterward a weather-beaten prospector, with pack horse, pick, shovel and gold pan, would traverse

the same ground and "strike it rich." But it is also well understood that the average professional geologist very much underrates the practical experience and "signs" of the prospector, and vice versa. If each would condescend to grasp and use the knowledge of the other in conjunction with his own, then better results would be obtained and mutual respect would exist between geologists and prospectors, which it can not be said to do to-day.

And although I am sure the abundance or sparsity of Eriogonum ovalifolium is no sign as to the presence or the absence of silver or other metal in the soil (for it grows in any formation, lime, sandstone, etc.), I would not presume to say the same of other "indicating plants," individually unknown to me.—F. W. ANDERSON, *Great Falls, Montana.*

Some western plants.—In examining some western collections recently, an interesting fact or two with respect to the range of certain plants has been brought to light. *Phlox Richardsonii* Hook., of the Arctic sea-coast, was found by Mr. F. W. Anderson, in May of this year, growing in great abundance upon Mt. Helena, Montana. It had previously been discovered by Scribner in the Belt Mountains, Montana. Mr. W. M. Canby's corps, on their northern transcontinental survey, discovered a form of Trautvetteria palmata, and now it turns up from Idaho, collected by J. B. Leiberg. *Pentstemon Lyallii* Gray, of British Columbia, and extending into the borders of Montana, has been sent in by Mr. J. B. Leiberg from Kootenai county, Idaho, growing on rocky banks, 3,000 to 6,000 feet altitude.—JOHN M. COULTER.

EDITORIAL.

A FEW writers are inclined to scatter their thoughts before the public with a too lavish hand. Facts of interest secured in an investigation are arranged to be presentable and ushered into the presence of the public through the medium of some society or journal. Without adding materially to the number of facts the language with which they are clothed is readjusted and another society or journal receives them. This shifting may be repeated several times, and the facts turn up in various places. Each time the reader, if not on his guard, will naturally suppose he is perusing the first and only statement of the kind, there being nothing to indicate that the author has already published other versions of the same matter. We do not have in mind the case where a paper read before a society is printed in a magazine to secure earlier publication, reference being made to the time and place of its first presentation; or to the case where an article is reprinted in one or more journals, due credit being given; or the case where an author writes up a part of a

subject, and subsequently presents another part; or the case where new facts are first published in a scientific journal and then worked over into popular form for the weekly press or any ephemeral publication. We are not thinking of these, but of the presentation of scientific facts in different journals, society reports, etc., under various guises, without adequately stating where and how they previously appeared. The neglect to take this precaution, when publication through one medium is not deemed sufficient, as usually ought to be the case, leads to much confusion and annoyance when another investigator goes over the same ground, and also has the effect of lowering the standard of appreciation with which thoughtful persons regard the author's writings. It suggests the idea that the author must be deficient in solid facts, or he would not require so much service of those he brings forward; and unpleasant suggestions also present themselves regarding the author's motives in thus using his material over and over. It may be supposed that scientific men of eminence would never fall into such practices, and yet conspicuous examples are not wanting.

OPEN LETTERS.

Vitality of seeds.

About twenty years ago, when "White Hall," upon the grounds of the Maine State College was built, the excavated dirt was used to make a fill, covering the surface of the ground four or five feet. This year, to lay some sewer pipes, a ditch was cut through the old fill, and along the side of the ditch, four feet below the present surface, seeds in considerable numbers germinated.

The plants did not develop sufficiently before the ditch was filled to determine the species.

F. L. HARVEY.

Orono, Maine.

The old and new botany.

In the April number of your magazine, the editorial on the methods of teaching botany attracted my attention. While heartily agreeing with the general sentiment expressed, I wish to offer some criticism, or call attention to that aspect of the new method which is considered, in some quarters at least, as the only true biological method.

You close the article with the sentence, "The botanical teaching of the future will consider these, not as two opposing methods, but as complementary, both essential to the rounding out of a botanical course." This implies that at the present time these two methods, the old and the new, may be considered as opposing each other. It seems to me we do not need to wait for the future to teach us that there can be no real opposition between them, for according to their definition in the editorial they refer simply to different departments of the same science. By the old method is meant the teaching of systematic botany, by the new, the teaching of types and the grounding in biological (physiological?) prin-

ciples. But biological work appears sometimes to be regarded as a science distinct from both botany and zoology, so that one not unfrequently hears of courses being planned in botany, zoology *and* biology, as though botany and zoology failed to recognize plants and animals as living things! Now this is what I do not believe, and it is this monopoly of vital phenomena set up by biologists for biology to which I object.

Now the new method, which is often referred to as the biological one, is supposed to include what is left out in the old, since they complement each other.

While I am unwilling to call it a *method* of teaching, it seems particularly unfortunate to call it the biological method. This word, as I understand it, belongs to the science by virtue of the objects considered being living things, therefore it is illogical to consider any department of botany as entirely unconnected with biology. To explain more fully, classification is based on morphology, or the doctrine of forms, the forms of the organs by which the plant is able to carry on its own existence and to reproduce its kind. It is as idle to consider the vital processes independently of the organs which exhibit them as it would be to ignore the functions of organs by dealing alone with their forms.

The opposition supposed to exist between the old and the new methods is the result of this misuse of the term biological, and it works harm in two ways: First, those wishing to take up the study of botany are deceived by supposing that there is a short, easy, new method, by which they are going to be led straight to the heart of the science without the tedious circumlocution of learning the names of things. It is natural that they should reject and oppose what they consider the old fashioned way. Secondly, this use of the term, biological method, is apt to lead to misunderstanding on the part of students, well educated in other respects, who are not especially interested in the biological sciences. To such the word protoplasm is destined to call up ideas of life-manifestations in which animals and plants either have no part or are inextricably confused.

As long as botanists are willing to suffer the most important part of botanical teaching to be referred to in such vague terms as to effectually disguise its real nature and even mislead educated people into supposing it can only be taught in connection with the science of animal life, so long will they find it difficult to give to botany the rank which it deserves. In France and Germany the study of the vegetable kingdom has been recognized, for some years, as a distinct science, including several departments; the terms, physiological, anatomical, morphological (which includes systematic botany), being used in a similar manner as in connection with zoology. In my judgment, if we were to follow their example and use these or similar terms when speaking of the different departments of botany it would do much toward obviating the two evils referred to. It would certainly help to place the science on a level with other natural sciences in the minds of those not especially interested, and would have some influence, perhaps, in rescuing botany from the general disfavor into which it appears to be falling. When the different parts of botany are not only referred to but taught in the way suggested, so that a general course will include a knowledge of all its departments, and an advanced course, continued study in any one or more of them, there will be no possibility of opposition, except the natural and healthful one of competition between those striving to do their best in their chosen fields.

EMILY L. GREGORY.

Bryn Mawr College.

CURRENT LITERATURE.

Pittonia, Vol. i, part 2. A series of botanical papers by Edward L. Greene, July, 1887, pp. 51–93.

When the first part of *Pittonia* appeared the question as to the meaning of the name was raised. This has called forth an explanation in the part before us, which explains that an easy name was sought, to be used in quoting, and so the family name of Tournefort was chosen. Two new genera of Borraginaceæ are proposed, *Oreocarya*, to include Krynitzkia § Pseudokrynitzkia and part of § Pterygium in Gray's Syn. Fl. Suppl.; and *Eremocarya*, to include Krynitzkia micrantha of Gray, and the var. lepida. The § Piptocalyx of Krynitzkia is restored to generic rank. Among miscellaneous species, new or rare, about twenty new ones are described. The part closes with an account of an excursion to the island of San Miguel, and a catalogue of its flowering plants.

Untersuchungen über Bau und Lebensgeschichte der Hirschtrüffel, Elaphomyces, von Dr. Max Rees und Dr. C. Fisch. Bibliotheca Botanica, Heft 7, quarto, pp. 24, pl. 1. Cassel, Theodor Fischer, 1887.

The obscure life history of truffles has received additional treatment by the authors, who corroborate the constant limitation of species of *Elaphomyces* to soil permeated by the roots of trees—according to their observation, pines—that are closely invested and parasitically attached by the growing mycelium, which matures its fruit only when in the most intimate connection with the abnormally branched rootlets. The connection between mycelium and roots appears to be simply that of a parasite with its host, and not a case of true symbiosis. Although plants were examined in large numbers, and in all stages of development, no trace of fertilization was observed, so that the fruit appears to be strictly nonsexual, as in the pileate fungi; but this retrogression has progressed further than in the latter, for many of the fruits fail to mature, and, though produced in myriads, the spores seem to have entirely lost the power of germination, and propagation is only known to be effected by the spreading of mycelial fibers from root to root.

Lectures on the Physiology of Plants. By Julius von Sachs; translated by H. Marshall Ward, M. A., F. L. S. Roy. 8°, pp. xv, 836; wood cuts 455. Clarendon Press, Oxford, 1887. (New York: Macmillan & Co.)

Again we are indebted to the Clarendon Press for an important aid to English speaking students of plant physiology. Sachs' admirable "Vorlesungen über Pflanzen-physiologie," issued in 1882, has been turned into excellent English by Prof. Ward, and thus added to the list of books essential to the working library of our laboratories. However much it is to be regretted, it is a fact that our American students can not make ready use of German books, and a translation is always welcome; particularly such a book as this, in which, in lecture form, the author sets forth

his own special views on physiology. Sometimes this personal treatment runs almost into egotism, though much is to be forgiven to one who has made such extensive and profound additions to our knowledge as Dr. Sachs. There is hardly an important topic upon which his researches have not cast much light, and for a large number of principles he justly claims priority.

But this work appeals not alone to the special student of plant physiology. It can be read by any person fairly well informed as to plant structure and the principles of chemistry and physics, and deserves as wide a circle of readers in its English form as it has had in Europe in its original German. To this the most admirable work of the translator commends it. We have him to thank also for the greatly extended index, an important part of a book, to which our German friends would do well to take better heed. We say nothing of the treatment of the work, taking it for granted that most teachers are already familiar with it, and that all who are not will at once obtain the new edition. The *imprimatur* of the Clarendon Press is a guarantee of the excellence of the typography. The volume is uniform with the recently issued Goebel's "Outlines of Classification," which is supplementary to it. With Goodale's, Vines' and Sachs' physiologies, English students have for the present a pretty full epitome of the functions of plants.

List of Works on North American Fungi, with the exception of Schizomycetes, published before 1887. By W. G. Farlow and William Trelease. Library of Harvard Univ.; Cambridge, 1887. 8°, pp. 36.

This reference catalogue, in its complete form, makes No. 25 of the Bibliographical Contributions of the Harvard library. It comes as a great boon to all students working upon the American fungal flora. Much of its value lies in the remarkable completeness and accuracy with which references to all independent works, articles, or incidental mention of American fungi, having scientific value, have been collated. Yet it is not supposed the list is perfect, and botanists will do their fellows, as well as the authors, good service by reporting omissions and corrections. A most difficult feature of the work has been to justly discriminate between articles having a modicum of scientifie value and those which are simply popular, which would on the one hand make the list imperfect if omitted, and on the other lumber it with useless references if included. We think the judgment of the compilers in this regard will not often be called in question.

The list includes about 650 numbers, some dozen of which are titles of journals, government reports, etc., and the remainder are titles of papers by 110 American and 73 foreign authors. Many of these works possess value in this connection by reason of a few paragraphs, subordinate statements, or mention of a few species—important matters to the investigator, and except for such an index most difficult to find. The list serves to correct a very prevalent misconception—an idea that the liter-

ature pertaining to American fungi is small and easily collected, and will also tend to set on their guard those who, with imperfect knowledge, rush into print with descriptions of supposed new species.

Over half the entries are the writings of fifteen authors, each of whom has contributed ten or more entries each. Two-fifths of these are foreigners, viz.: Fries 11 entries, Von Thümen 11, Winter 12, Saccardo 13, Berkeley 30 and Cooke 71, total 148 entries; while three-fifths are Americans, viz.: Arthur 10 entries, Bessey 11, Leidy 11 (all pertaining to fungi parasitic on animals), Gerard and Trelease 12 each, Burrill 17, Farlow 31, Peck 40 and Ellis 50, total 194 entries.

The slight biographical item of dates of birth, and in some cases of death appended to each author's name (with 43 exceptions) has its value. It brings out the interesting fact that over one-fourth of the American writers enumerated (excluding the twenty four names without data) were born either during or since 1850, and constitute 35 per cent. of those living at the beginning of the present year. They are also represented in the list of chief writers mentioned above. The large percentage of young investigators obviously promises an accelerated development of this field of science. Only four foreign writers occur whose births do not antedate 1850, of whom Bagnis, now dead, Pirotta and Voglino are Italians, and Rostafinski a Pole.

Other interesting statistics might be gleaned from this list, but space forbids. A supplement gives an account of ten exsiccati, three American and the others containing American specimens.

Every student of fungi will feel that he is indebted to the compilers for a valuable service, and one no other botanists were in position to perform so acceptably.

NOTES AND NEWS.

PROF. G. C. WITTSTEIN died at Munich on June 1, in his seventy-eighth year.

A CORRESPONDENT of the *Revue Horticole* reports the growth of mistleto on an old peach tree.

IN THE *Journal of Botany*, for September, R. Miller Christy has a paper entitled "Notes on the botany of Manitoba."

DR. H. MAYR, of the Forestry Institute of the University of Munich, has accepted a professorship in the University of Tokio.

DR. H. VÖCHTING, author of numerous important botanical works, has been made professor of botany at the University of Tübingen.

MR. TOKATURO ITO gives an interesting account, in *Journal of Botany*, of the history of botany in Japan. It is accompanied by a portrait of Ito Keisuke.

M. PIERRE VIALA, of Montpelier, France, an investigator of eminence, is visiting this country to study the diseases of the grape and of other cultivated plants.

COPIES of the desiderata (Ranunculaceæ to Rosaceæ incl.) of the herbarium of the Department of Agriculture, can be had on application to the Commissioner of Agriculture.

DR. V. F. KOSTELETZKY, professor of botany at Prague, died August 18, aged 87. It will be remembered that our malvaceous genus Kosteletzkya was named in his honor by Presl.

AT THE RECENT meeting of the British Association Count Solms-Laubach described a genus of fossil plants (Bennettites), the type of a new group between Angiosperms and Gymnosperms.

THE FINDING of Grindelia squarrosa at Evanston, Ill., is recorded by L. N. Johnson in *Science* for September 23. It is a common plant in western Iowa and Minnesota, and especially on the plains of Dakota.

MR. JAMES E. HUMPHREY, Dr. Goodale's assistant in the summer school of botany at Cambridge last summer, has been appointed instructor in botany at the State University, Bloomington, Ind., and has entered upon his duties there.

AT THE recent Manchester meeting of the British Association the following grants were made for botanical work: Botany (and zoology) of the West Indies, £100; flora of China, £75; flora of Bahamas, £100; Peradenyia botanical station, £50.

THE LECTURE of Miss Helen C. De S. Abbott, on "Plant chemistry as illustrated in the production of sugar from sorghum," has been distributed as a reprint from the proceedings of the alumni association of the Philadelphia College of Pharmacy.

THE FIRST NUMBER of the *Annals of Botany* contains papers by Prof. Marshall Ward, Mr. Walter Gardiner and Mr. Tokaturo Ito, Miss Calvert and Mr. L. A. Boodle, Messrs. Gregg, F. W. Oliver, Reynolds, Blake and Prof. Bayley Balfour. Prof. Ward's paper is on the histology and fruits of Rhamnus.

MILLSPAUGH'S American Medicinal Plants is completed with the appearance of the sixth fascicle. The work is a valuable one, has been well done, and should be a great help to homœopathic physicians. It contains 188 colored illustrations, and complete text, of all the plants indigenous and naturalized in the United States, which have been proven and incorporated in the Homœopathic Materia Medica.

A NEW PERIODICAL devoted to botany has just been issued at St. Petersburg. It is published in connection with the botanical garden of St. Petersburg University, the editors being Profs. Beketoff and Gobi. The title is *Scripta Botanica Horti Universitatis Petropolitanæ*, which in reference will be abreviated to *Scripta Botanica*. A welcome feature is that papers in Russian are followed by abstracts in French or German.

THE SOURCE of nitrogen in Leguminosæ has long been an interesting question. M. Hellriegel has attributed it to bacteria found abundantly in the well-known tubercles on the roots of this family. His experiments showed that plants deprived of bacteria were starved, while those which

had the benefit of them flourished, and the tubercles were highly developed. It will be remembered that Prof. H. Marshall Ward (Bot. Gaz. xii. 235) refers these so-called bacter a to the germs of a fungus related to Ustilago. In either case the tubercles seem to have to do with the nitrogen supply.

Dr. George Volkens has published a series of observations on the plants of the Egyptian and Arabian desert. According to *Gardener's Chronicle* the physiological history of the plants is given in relation to the absorption and transpiration of water, the assimilation or digestion of food, the mechanical frame-work, etc. All these phenomena are more or less modified to suit the remarkable climatal conditions that prevail.

In his synopsis of Tillandsieæ, in the *Journal of Botany*, Mr. J. G. Baker has completed eighty-eight species of Tillandsia, of which twenty-four are new. Of these new species six come from Mexico, one of which bears the familiar name T. Parryi, having been discovered in Central Mexico by Parry and Palmer. The *T. juncea* Le Conte, and *T. Bartramii* Ell., of Chapman's Flora, become *T. setacea* Sw., while *T. bracteata* Chapm. is *T. fasciculata* Sw.

The red patches on the leaves of Chenopodium album, the common pig weed, is found by Prof. H. Osborn, of the Iowa Agricultural College (*Science* for September 30), to be associated with larvæ of the same color, belonging to the leaf-hopper, *Thamnotettix seminudus* Say. Although the insect is quite common, it seems to have heretofore escaped observation in its larval form. The conjecture is hazarded that it is the cause of the change of color in the leaves.

The astonishing activity of our friends of the Pacific coast does not abate, and parts of Pittonia and Bulletins of the California Academy of Science appear with unexpected frequency. The sixth contribution of Prof. E. L. Greene, entitled "Studies in the botany of California and parts adjacent," has now come to hand, containing (1) notes on the botany of Santa Cruz Island, (2) a catalogue of the flowering plants and ferns of the Island of Santa Cruz, (3) three new species.

The *Bulletin of Miscellaneous Information*, begun to be issued in monthly parts from Kew Gardens, has now reached its ninth, or September number. The object is to give notes on economic products and plants to which attention has been drawn in the correspondence or work at Kew. The last number contains two parts, xvii—Annotto (*Bixa Orellana* L.), and xviii—Notes on articles contributed to the museum of the Royal Gardens, Kew, from the Colonial and Indian Exhibition, 1886. Only cranberries and buffalo berries were received from Canada.

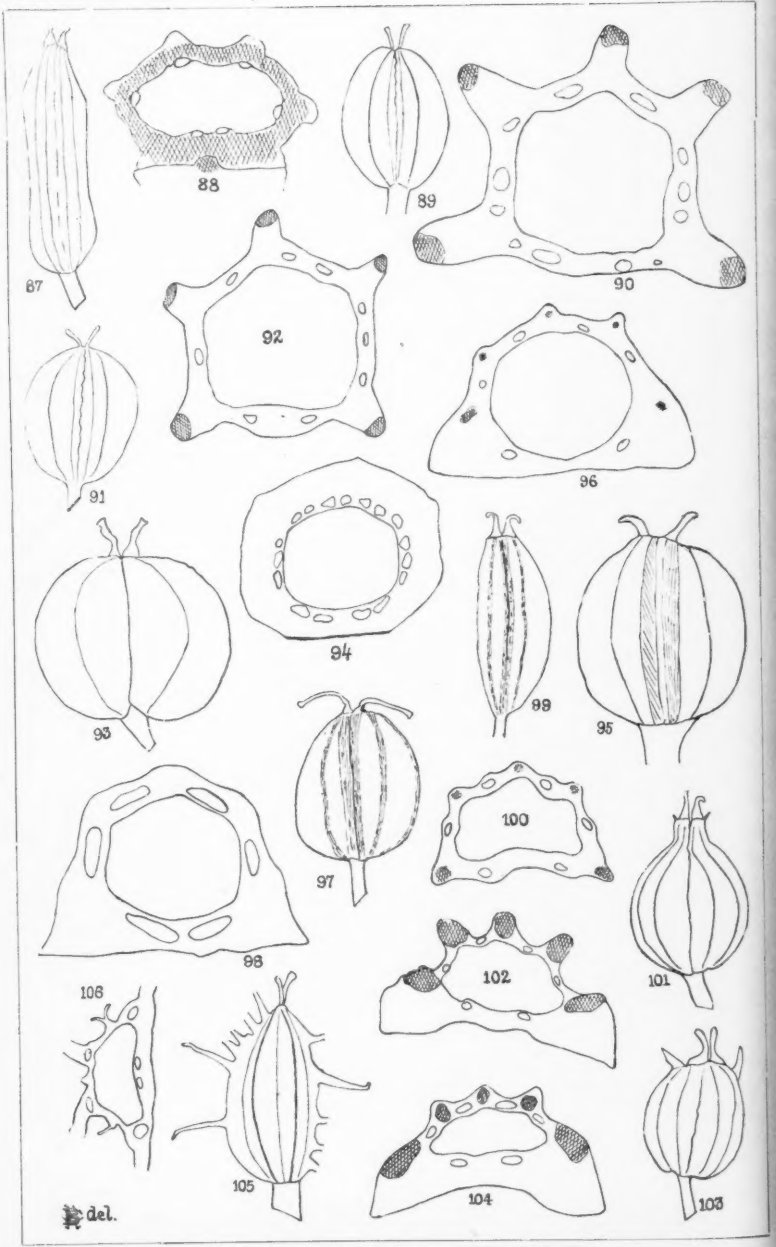
Dr. C. C. Parry has just distributed a partial revision of the *Uva-ursi* section of Arctostaphylos, as represented on the Pacific coast. In it A. pungens of various authors (not HBK.) becomes *A. Manzanita* Parry; A. glauca, in part, of various authors (not Lindl.) becomes *A. viscida* Parry; *A. Standfordiana* Parry is a new species heretofore confounded with A. glauca; *A. insularis* Greene, in herb., is a new species from the island of Santa Cruz; and *A. Pringlei* Parry is from Lower California. *A. pungens* HBK. is Mexican.

Some recent researches of Molisch on the fall of leaves, as summarized in the *Bot. Zeitung* for July 29, are of interest. Molisch finds the formation of the separating layer to be chiefly dependent upon unusual

variations in the amount of transpiration, or to the diminution of the water-content of the leaf, produced by injury or disease of the roots or stem. The direct influence of absence of light is comparatively slight, and the relation between temperature and defoliation was not fully enough tested to be established. Of two series of experiments the higher temperature (17°–22°C.) promoted the fall of the leaves. The presence of oxygen is necessary to the development of the separating layer. The author holds that the separation of the cells of the separating layer is due to a solution of the middle lamella, by action of a ferment rather than by resorption of the wall.

GEORGE MASSEE, in *Journal of Botany*, has a paper on causes influencing the direction of growth, and the origin of multicellular plants. His conclusions are that, as experimentally proved in the case of Œdogonium, the normal method of cell-formation is due to the unyielding nature of the external sheath. "The influence of the sheath is not to be considered as the only factor in determining the direction of growth or habit of a plant, but rather that the initial idea of direction and multicellular structure were due to it, and in the simplest as also the unbranched filamentous forms, its influence predominated, but in the latter is modified by the increased power manifested by the protoplasm in softening or completely dissolving certain portions of the sheath for various purposes connected with reproduction," as in the beak of Vaucheria and the conjugating tube of Spirogyra.

DR. J. VON SACHS gives in *Arbeit. Bot. Inst. Würzburg* (iii. 372-388), the details of the experiments from which he concludes that the invisible ultra-violet rays of the solar spectrum are especially efficacious in the development of flowers. The experiments were all made on Tropæolum majus. If the rays of the sun are made to pass through a solution of sulphate of quinine the ultra-violet rays are entirely absorbed or transformed into rays of less refrangibility which are visible and of a light blue color. If a plant is made to grow behind a screen of sulphate of quinine the vegetative organs are normally and luxuriantly developed, but the flowers are almost entirely suppressed. Twenty-six plants thus grown produced only a single feeble flower, while twenty plants grown under similar conditions behind a screen of water of the same thickness produced fifty six flowers. * * * It may be assumed then that there are three distinct regions of the solar spectrum differing in their physiological action—the yellow rays and those near them cause the decomposition of carbon dioxide, and are active in assimilation; the blue and the visible violet rays are the agents in the movements of irritation; the ultra-violet rays are those which produce in green leaves the substances out of which flowers are developed.—*Jour. Roy. Mic. Soc.*, Aug.



COULTER and ROSE on UMBELLIFERÆ.